Spin-Orbit Torques in Ferrimagnetic CoTb alloys

Soong-Geun Je[1,2*], J-C. Rojas-Sánchez[2], T. H Pham[2], P. Vallobra[2], T. Fache[2], M.-C. Cyrille[3], D. Lacour[2], G. Malinowski[2], M. Hehn[2], G. Gaudin[1], S. Mangin[2] and O. Boulle[1]

[1]SPINTEC, CEA-INAC/CNRS/Univ. Grenoble Alpes, 38054 Grenoble, France

[2]Institut Jean Lamour, UMR 7198 CNRS-Université de Lorraine, 54506 Vandoeuvre lès Nancy, France

[3]CEA-LETI, 38054 Grenoble, Franc

Spin-orbit torque (SOT) has been of great interest as an efficient means of manipulating magnetization in heavy metal/ferromagnet bilayers. Recently, as a strategy of reducing the switching current density, ferrimagnetic and antiferromagnetic materials are attracting attention due to the expectation of minimizing net magnetization and hence reducing the angular momentum required to switch the magnetization. In addition, the immunity to the external magnetic field really makes these systems promising materials for future spintronic memory devices.

Here we demonstrate the SOT-induced magnetization switching and the effective field in W(3nm)/CoxTb1-x (3.5nm)/AlOx(3nm) perpendicular ferrimagnetic alloys. In order to see how the SOT changes as it passes across the magnetic compensation point, a series of CoTb alloys with a wide range of compositions are prepared using DC magnetron sputtering. The films are then patterned into Hall cross structure to exploit the anomalous Hall effect as a means of probing the magnetization in this compensated magnetic system.

First, the SOT switching is achieved nicely in all samples. Particular, the SOT switching is accomplished even in the sample which has an extremely huge coercive field and anisotropy field with a quite low current density and a tiny in-plane field, suggesting the efficient SOT mechanism. After quantifying the SOT-induced effective field, we find that the effective field scales with the inverse of magnetization, implying the angular momentum conservation still holds in the CoTb system where the spin-orbit coupling is presumed to be large. Apart from this, the effective spin Hall angle is found to increase with increasing Tb concentration, indicating there is an additional influence of SOT coming from Tb atoms.

To conclude, the SOT can serve as a powerful method to encode information in ferrimagnetic materials, enabling realization of highly stable memory devices.